

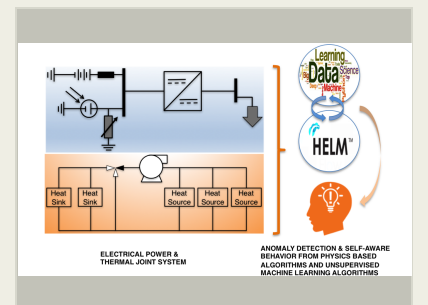
# Holomorphic Embedding for Loadflow Integration of Operational Thermal and Electric Reliable Procedural Systems, Phase I

Completed Technology Project (2017 - 2018)



## Project Introduction

This sound, low risk proposal aims at developing technology for the fundamental modeling and data processing needs of future autonomous operation. It addresses problems of early anomaly and fault detection in PMAD systems, adopting a larger scope by also including the thermal system. Truly autonomous operation of large power systems (e.g. ISS) cannot be scripted. In the quest to replace expert human operator functions by intelligent applications capable of self-healing and management, two key pillars are prerequisites to achieve a sufficient degree of correct self-aware behavior: a reliable model of internal system behavior, and efficient and reliable ways to deal with external and internal information. On these areas, the innovation will extend the ideas behind the Holomorphic Embedding Loadflow Method (HELM, which solves non-equivocally the steady-state equations of electrical power systems), to encompass a larger heterogeneous system: the joint electrical and thermal system. Rationale: being both critical and inter-dependent, they need a holistic approach. The innovation builds first on their joint operational physical model, seen as algebraic equations. The focus will be on its eventual future use as the computational engine for autonomous operation applications. HELM is a computational engine in intelligent decision-support for operations in transmission grids, and is currently being adapted to spacecraft DC grids. The second innovation context is data processing for self-aware behavior algorithms, proposing convergence of the physical model-based approach (HELM) and emerging unsupervised Big Data/Machine Learning techniques. Having experts from both worlds, these approaches will reinforce each other—not only by means of feeding results to each other, but also in internal work models. RI(UMD) technology transfer on Multi-Task Learning, electric storage and aircraft guarantees success



Holomorphic Embedding for Loadflow Integration of Operational Thermal and Electric Reliable Procedural Systems, Phase I Briefing Chart Image

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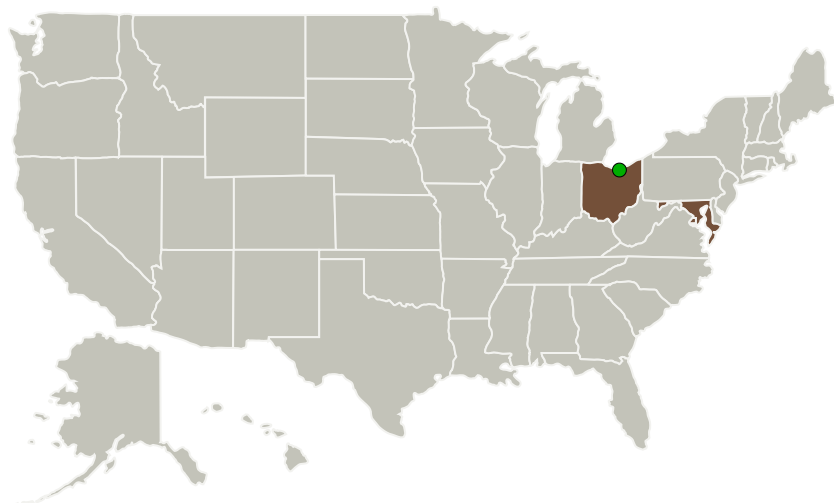
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## Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
EleQuant Knowledge Innovation Data Science, LLC	Lead Organization	Industry	Washington, District of Columbia
● Glenn Research Center(GRC)	Supporting Organization	NASA Center	Cleveland, Ohio
University of Maryland-College Park(UMCP)	Supporting Organization	Academia Asian American Native American Pacific Islander (AANAPISI)	College Park, Maryland

Primary U.S. Work Locations	
District of Columbia	Maryland
Ohio	

## Organizational Responsibility

### Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

### Lead Organization:

EleQuant Knowledge Innovation Data Science, LLC

### Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

## Project Management

### Program Director:

Jason L Kessler

### Program Manager:

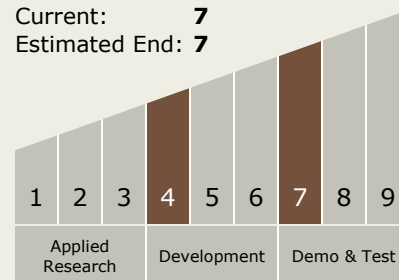
Carlos Torrez

### Principal Investigator:

Antonio Trias

## Technology Maturity (TRL)

Start: 4  
Current: 7  
Estimated End: 7

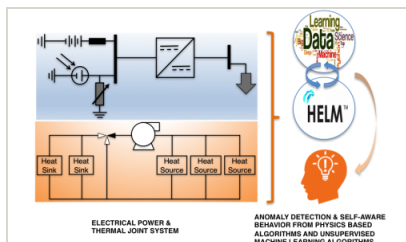


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## Images



### Briefing Chart Image

Holomorphic Embedding for Loadflow Integration of Operational Thermal and Electric Reliable Procedural Systems, Phase I

Briefing Chart Image

(<https://techport.nasa.gov/image/126195>)

## Technology Areas

### Primary:

- TX03 Aerospace Power and Energy Storage
  - └ TX03.3 Power Management and Distribution
    - └ TX03.3.1 Management and Control

## Target Destinations

The Sun, Earth, The Moon, Mars, Others Inside the Solar System, Outside the Solar System